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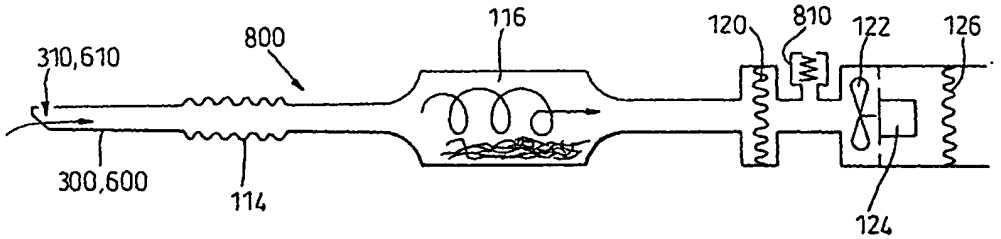
(54) Title: A VACUUM CLEANER



(57) Abstract: A vacuum cleaner comprises a cyclonic separator (116) for separating dirt and dust from an incoming airflow. A tool (300) and a suction conduit (114) connect the tool (300) to the separator (116). The tool (300) comprises a main air inlet aperture for engaging with a surface to be cleaned and a bleed air inlet (310) for allowing air to bleed into the suction path. The bleed air inlet (310) is located such that it is separate from the main inlet. The cross-sectional area of the bleed air inlet (310) is sufficiently large that, in use, the bleed air inlet (310) admits a sufficient quantity of air to maintain adequate separation efficiency in the separator of the cleaner even when the main air inlet is fully blocked.

WO 02/067746 A1

A Vacuum Cleaner

This invention relates to a vacuum cleaner.

Vacuum cleaners are usually supplied with a range of tools for use with various cleaning situations that a user may encounter. An upright vacuum cleaner has a wide, floor-engaging cleaner head at the base of the cleaner which is used for general floor cleaning. A range of smaller tools may also be supplied with the machine. These are usually attached to the end of a flexible hose of the cleaner. The tools often include a crevice tool for use in narrow, confined spaces, a stair tool and an upholstery tool with a brush head. A cylinder or canister vacuum cleaner has a wide floor tool which is attached to the end of a cleaning wand for general floor cleaning and a similar range of smaller tools for use in other cleaning situations.

For any vacuum cleaner, it is important to maintain a good flow rate of air into the floor tool and along the suction path of the cleaner in order to maintain good cleaning performance. This is particularly important with a cleaner that relies on cyclonic or centrifugal separation as the flow rate of dust-laden air within the cyclonic separating chamber is an important factor in determining the efficiency of the dust separation. It is known for tools to include one or more bleed air inlets. As shown in Figure 1, the air inlet of a crevice tool 10 has a flat portion 12 and a notched portion 14. The notched portion 14 ensures that some air flows into the tool 10 even when the flat portion 12 is sealed against a surface.

Figure 2 schematically shows a known type of cyclonic vacuum cleaner. The vacuum cleaner 100 incorporates a floor tool 10 which is attached directly to a hose 114. The hose 114 is directly connected to dust-separating apparatus 116. The dust-separating apparatus 16 is a cyclonic separating apparatus using one or more cyclonic separation stages. Downstream of the dust-separating apparatus 116 is a pre-motor filter 120, followed by a fan 122 which is driven by a motor 124. A further filter 126 is located after the motor 124. A bleed valve 118 is located on the dust-separating apparatus. The

bleed valve 118 is arranged to admit air into the separating apparatus when the flow of air along the airflow path is significantly reduced. The bleed valve can respond to the pressure along the airflow path reducing to a predetermined absolute value, or to the difference in pressure between two parts of the airflow path reaching a predetermined value.

In use, the motor 124 operates to activate the fan 122 which causes a flow of air to pass from the floor tool 10 to the dust-separating apparatus 116 via the hose 114. After separation has taken place, the airflow passes through the pre-motor filter 120, past the fan 122, past the motor 124 providing a cooling effect, and through the post-motor filter 126 before being expelled to the atmosphere. A bleed valve 118 is arranged such that, if the pressure within the dust-separating apparatus 116, and particularly at the location within the dust-separating apparatus 116 at which the bleed valve 118 is placed, drops below a pre-determined value, the bleed valve 118 opens so as to allow air from the atmosphere to enter the cyclonic dust-separating apparatus in order to maintain an adequate airflow to effect separation. The prevention of the airflow from falling below a predetermined level helps to ensure that the motor 124 is adequately cooled so as to prevent any risk of overheating in the event of a blockage occurring in the airflow path upstream of the bleed valve 118.

However, the provision of a bleed valve, particularly a pressure differential bleed valve, adds considerable cost to the cleaner. Also, since the bleed valve has movable parts it is prone to wear and degradation over a period of use.

The present invention seeks to obviate the need for a bleed valve along the airflow path to the separator.

Accordingly, the present invention provides a vacuum cleaner comprising a cyclonic separator for separating dirt and dust from an incoming airflow, a tool and a suction conduit for connecting the tool to the separator, wherein the tool comprises a main air inlet aperture for engaging with a surface to be cleaned and a bleed air inlet for allowing

air to bleed into the suction path, the bleed air inlet being located such that it is separate from the main inlet and wherein the cross-sectional area of the bleed air inlet is such that, in use, it admits a sufficient quantity of air to maintain adequate separation efficiency in the separator of the cleaner when the main air inlet is fully blocked.

The bleed air inlet admits a sufficient quantity of air to maintain adequate separation efficiency in the vacuum cleaner, even when the main air inlet to the tool is fully blocked. This is particularly important in a vacuum cleaner which uses a set of small, parallel cyclonic separators where there is a risk that the separators could become blocked if the flow rate reduces below a critical value since the vortex cannot form. Also, the provision of a continuous flow of bled air through the tool into the suction path reduces or avoids sudden changes in airflow through the separation apparatus, which minimises the risk of dirt becoming re-entrained in the airflow through the separator. This extends the life of filters placed after the separation apparatus. The provision of the bleed air inlet can also avoid the need for a bleed air valve located further downstream along the suction path, which reduces the overall cost of the cleaner. The continuous provision of bled air also reduces the force that is required by a user to push the tool along a surface.

Preferably the bleed air inlet of the tool is located such that it is spaced from the main air inlet and directs air into the suction channel towards the main aperture. The bleed air inlet can be located on the upper face of the housing. This position of the bleed air inlet ensures that the bled air helps to agitate the surface that is being cleaned and thus results in more dirt, fluff and other debris being removed from the surface. Thus, it can be seen that the provision of the bleed air inlet improves the cleaning performance of the tool at all times, whether the main inlet is blocked or not.

Preferably the bleed air inlet is a plurality of apertures. These can be spaced across the tool. The inlets may differ in their height from the main aperture.

Preferably the bleed air inlet or inlets has a guide channel for guiding the flow of air.

It has been found that providing the bleed air inlet in a direction which is substantially perpendicular to the plane of the main air inlet aperture provides a particularly effective cleaning effect. It has also been found that the angle of the bleed air inlet with respect to the longitudinal axis of the air outlet has an effect on the cleaning performance of the tool. By aligning the bleed air inlet such that it points away from the longitudinal axis of the outlet, a greater proportion of the bled air is likely to strike or to pass through the floor surface beneath the main air inlet. It has been found particularly beneficial to cause the bled air to flow through an obtuse angle, and preferably an angle approaching 180°.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a known type of tool for a vacuum cleaner;

Figure 2 schematically shows the parts of a known cyclonic vacuum cleaner;

Figures 3 and 4 show a first embodiment of a tool which can be used in the present invention;

Figure 5 is a cross-section through the tool of Figure 3;

Figures 6 to 8 show a second embodiment of a tool which can be used in the present invention;

Figures 9 and 10 are cross-sections through the tool of Figure 6;

Figure 11 schematically shows a cyclonic vacuum cleaner using the floor tools of Figures 3 to 10;

Figure 12 shows a further tool which can be used in the invention.

Figures 3 to 5 show a stair tool 300 which is used for cleaning stairs and areas which cannot readily be reached by a full-sized floor tool. Figure 5 shows a cross-section along A-A of Figure 4. The tool has a body with a neck 301 for connecting to a suction hose or wand of a vacuum cleaner. The lower face of the tool has a main suction opening 330 which is intended to be pressed against a surface which is to be cleaned. A comb 320 is positioned within the suction passageway 350 and extends downwardly towards the main suction opening 330. The comb has a formation of alternate fingers and openings when viewed in the direction X of Figure 4, the fingers extending towards the suction opening 330. The cross-section of Figure 5 shows the lowermost extent of one of the fingers of the comb. The comb serves to agitate the floor surface when it is pushed forwards and backwards across the surface. A set of bleed air inlets 310 are located across the width of the tool 300. Each of these inlets extend from the upper face towards the main suction opening 330. The inlets 310 in this tool are perpendicular to the plane of the main suction opening 330. A pathway exists between the lowermost part of the bleed air inlets and the main passageway 350, through the comb 320. This pathway exists even when the tool is pressed fully against a surface. Eight inlets are shown, spaced across the full width of the tool, but other numbers of inlets are possible. The inlets could be confined to only part of the width of the tool but we have found best results are achieved when the inlets are spaced across the full width of the tool.

In use, air is drawn through the main suction opening 330. This airflow passes through the pile of a carpeted surface, carrying dirt and dust with it, and then flows along passageway 350 towards the cleaner. A secondary flow of air enters the tool via inlets 310. This secondary air or bled air is directed towards the surface which is pressed against the main suction opening 330. Some of the air will be drawn through the pile of the carpeted surface before flowing along passageway 350. Other air may flow directly from inlet 310 to passageway 350, bypassing the carpeted surface. The combination of air being drawn through the surface from the sides and above helps to increase the agitation of the floor surface. Also, air will still be able to freely flow into the tool via

inlets 310 when the surface is very thickly piled and when there is little or no flow in direction 360.

Figures 6 to 8 show a crevice tool, with Figure 8 showing a cross-section along B-B of Figure 6. A crevice tool is typically used to clean confined areas. The tool has a body with a neck 601 for connecting to a suction hose or wand of a vacuum cleaner. The lower face of the tool has a main suction opening 630 which is intended to be pressed against a surface which is to be cleaned. A set of bleed air inlets 610 are located on the lowermost part of the upper surface of the tool 600, the inlets being positioned one behind the other. Each of these inlets 610 extend from the upper face towards the main suction opening 630. Both the entry to the inlets and the exits from the inlets increase in height from the opening 630. The inlets 610 in this tool are set at an angle of around 70° to the plane of the main suction opening 630 although this angle could be perpendicular, as with the tool of Figure 3, or some other angle. The inlets 610 are directed away from the longitudinal axis of the main passageway 650, thus ensuring that air which flows into the tool via inlets 610 is forced to make a 'u-turn' of 155° in order to flow out of the tool along the passageway 650. This is shown more clearly in Figure 10. A pathway exists between the lowermost part of the bleed air inlets and the main passageway 650. This pathway exists even when the tool is pressed fully against a surface. Four inlets are shown, but other numbers of inlets are possible.

In use, this tool works in a similar manner to the tool of Figures 3-5. Figure 9 shows the main directions of airflow and Figure 10 shows a more detailed plot of airflow. Air is drawn through the main suction opening 630. This airflow passes through the pile of a carpeted surface, carrying dirt and dust with it, and then flows along passageway 650 towards the cleaner. A secondary flow of air enters the tool via inlets 610. This secondary air or bled air is directed towards the surface which is pressed against the main suction opening 630. Some of the air will be drawn through the pile of the carpeted surface before flowing along passageway 650. Other air may flow directly from inlet 610 to passageway 650, bypassing the carpeted surface. The combination of air being drawn through the surface from the sides and above helps to increase the

agitation of the floor surface. Also, air will still be able to freely flow into the tool via inlets 610 when the surface is very thickly piled and when there is little or no flow in direction 660. The plot of Figure 10 clearly shows that air is directed towards and, in part, through the surface to be cleaned rather than simply flowing directly from the inlet 610 to the passageway 650 and bypassing the surface.

Figure 11 schematically shows a cyclonic vacuum cleaner 800 which uses the tools described above.

The principle of cyclonic separation in domestic vacuum cleaners is described in a number of publications including EP 0 042 723. In general, an airflow in which dirt and dust is entrained enters a first cyclonic separator via a tangential inlet which causes the airflow to follow a spiral or helical path within a collection chamber so that the dirt and dust is separated from the airflow. Relatively clean air passes out of the chamber whilst the separated dirt and dust is collected therein. In some applications, and as described in EP 0 042 723, the airflow is then passed to a second cyclone separation stage which is capable of separating finer dirt and dust than the upstream cyclone. The airflow is thereby cleaned to a greater degree so that, by the time the airflow exits the cyclonic separating apparatus, the airflow is almost completely free of dirt and dust particles.

In Figure 11, most of the parts of the cleaner are the same as shown in Figure 1 and have the same reference numbers. However, the tool 10 has been replaced by one of the tools 300, 600 which have bleed air inlets. Since air can now flow along the airflow path even when the main inlet of the tool is blocked, effective separation can be maintained in separation apparatus 116 without the need for the bleed valve 118. A bleed valve 810 can be fitted downstream of the separator and pre-motor filter 120 to ensure that the motor will not overheat when the filter 120 becomes blocked. The cross-sectional area of the bleed air inlets 310, 610 is chosen such that, even when the main air inlet is fully sealed against a surface, the flow rate of air through the tool will be sufficient to maintain adequate separation efficiency in the dust-separating apparatus of

the cleaner. It has been found that dimensioning the inlets 310, 610 to ensure a minimum flow rate of 20 litres per second through the tool provides good separation.

As an alternative to what is shown in Figure 11, the bleed valve 118 of Figure 1 could be used in its original position along with the tools 300, 600. The increased cleaning performance of the tools provides a beneficial effect, and the bleed valve 118 opens in the event that a blockage occurs somewhere between the tools 300, 600 and the dust-separating apparatus.

Figure 12 shows a cross-section through a further embodiment of a tool. The tool has a body 705 with a neck 701 for connecting to a suction hose or wand of a vacuum cleaner. The lower face of the tool has a main suction opening 730 which is intended to be pressed against a surface which is to be cleaned. A set of bleed air inlets 710 are located on the lowermost part of the upper surface of the tool 700. Each of these inlets 710 extend from the upper face towards the main suction opening 730. This embodiment differs from those previously described in that a brush 740 is positioned within the housing and extends towards the plane of the suction opening 730. The bleed air inlets 710 are directed such that bled air will strike the carpet at the base of the brush, thus subjecting the surface to agitation by both the brush and the bled air. The inlets 710 in this tool are set at an angle of around 45 -60° to the plane of the main suction opening 730, although this angle could be varied. A pathway exists between the bleed air inlets and the main passageway 750, through the brush 740. This pathway exists even when the tool is pressed fully against a surface. Rollers 720 are mounted to the lower surface of the tool 700 to minimise the 'push force' which a user must exert to move the tool. Other parts of the lower surface of the tool which may come into contact with the surface can be coated with a low-friction material such as PTFE to further reduce resistance.

Claims

1. A vacuum cleaner comprising a cyclonic separator for separating dirt and dust from an incoming airflow, a tool and a suction conduit for connecting the tool to the separator, wherein the tool comprises a main air inlet aperture for engaging with a surface to be cleaned and a bleed air inlet for allowing air to bleed into the suction path, the bleed air inlet being located such that it is separate from the main inlet and wherein the cross-sectional area of the bleed air inlet is such that, in use, it admits a sufficient quantity of air to maintain adequate separation efficiency in the separator of the cleaner when the main air inlet is fully blocked.

2. A vacuum cleaner according to claim 1 wherein the bleed air inlet of the tool is located such that it is spaced from the main air inlet and directs air into the suction channel towards the main aperture.

3. A vacuum cleaner according to claim 1 or 2 wherein the bleed air inlet is located on the upper face of the housing.

4. A vacuum cleaner according to any one of the preceding claims wherein the bleed air inlet is a plurality of apertures.

5. A vacuum cleaner according to claim 4 wherein the plurality of apertures are spaced across the tool.

6. A vacuum cleaner according to claim 4 or 5 wherein the inlets differ in their height from the main aperture.

7. A vacuum cleaner according to any one of the preceding claims wherein the bleed air inlet has a guide channel for guiding the flow of air.

8. A vacuum cleaner according to any one of the preceding claims wherein the bleed air inlet is directed in a direction which is substantially perpendicular to the plane of the main air inlet aperture.

9. A vacuum cleaner according to any one of the preceding claims wherein an agitator is mounted within the housing for agitating a surface.

10. A vacuum cleaner according to claim 9 wherein the bleed air inlet is located such that it directs bled air towards the distal end of the agitator.

11. A vacuum cleaner according to claim 9 or 10 wherein the agitator is a brush.

12. A vacuum cleaner according to any one of the preceding claims wherein the angle between the bleed air inlet and the air outlet is greater than 90°.

13. A vacuum cleaner according to any one of the preceding claims wherein the cross-sectional area of the bleed air inlet is sufficient to allow, in use, a flow rate of at least 20 litres per second through the tool.

14. A vacuum cleaner according to any one of the preceding claims wherein the cyclonic separator comprises a set of parallel cyclonic separators and the cross-sectional area of the bleed air inlet is sufficient to allow, in use, a flow rate above that at which the separators would become blocked.

15. A vacuum cleaner according to any one of the preceding claims wherein the floor tool is a crevice tool or a stair tool.

16. A vacuum cleaner substantially as described herein with reference to the accompanying drawings.

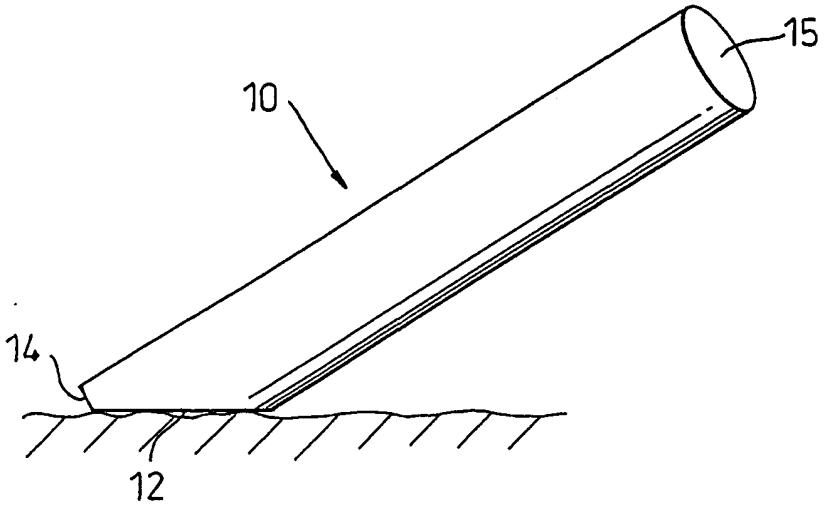


Fig. 1

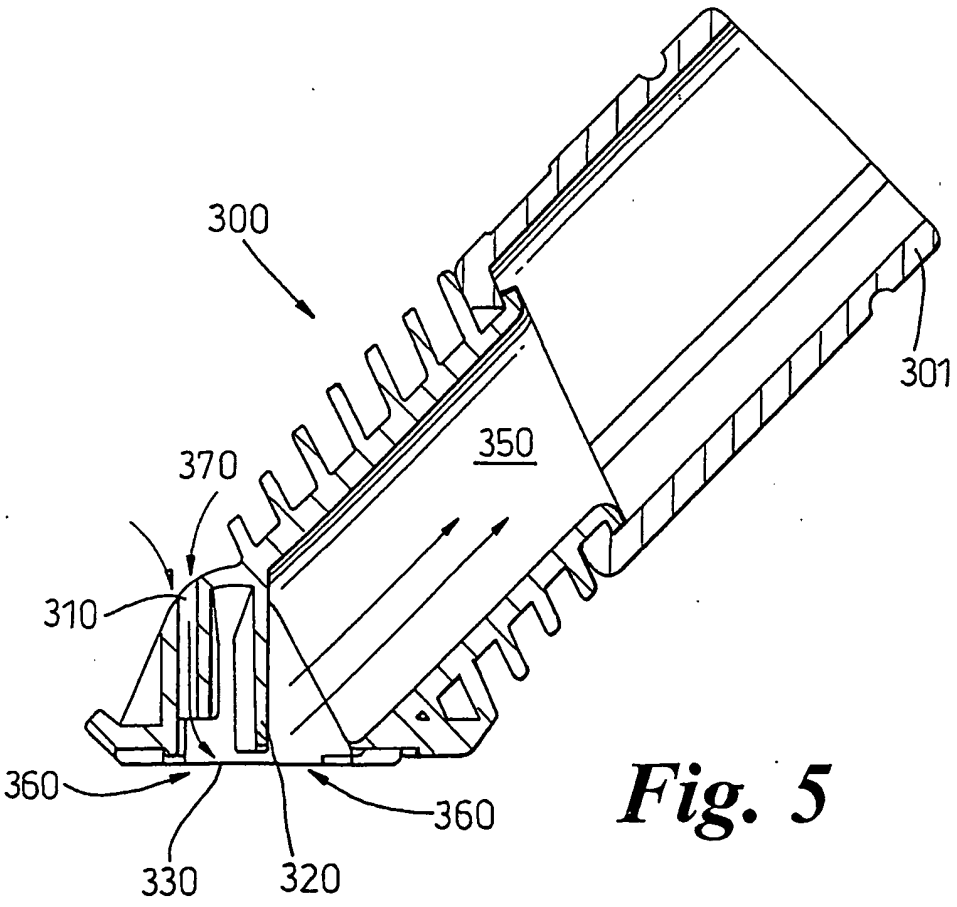


Fig. 5

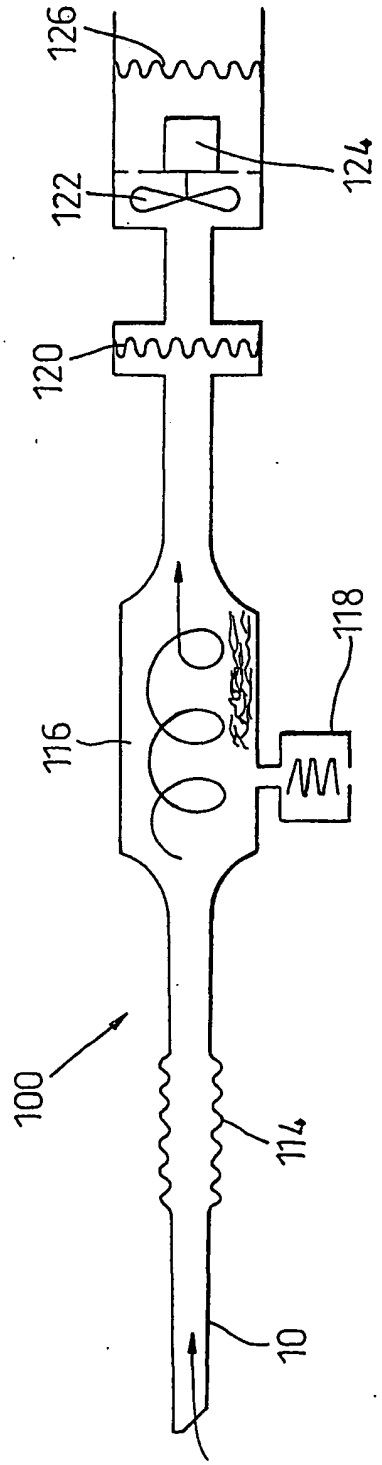


Fig. 2
(PRIOR ART)

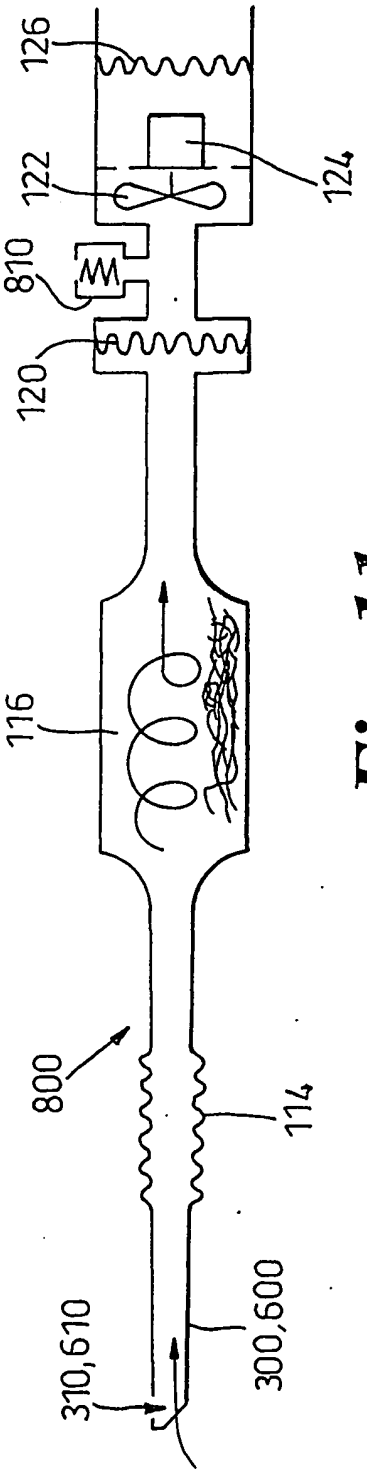


Fig. 11

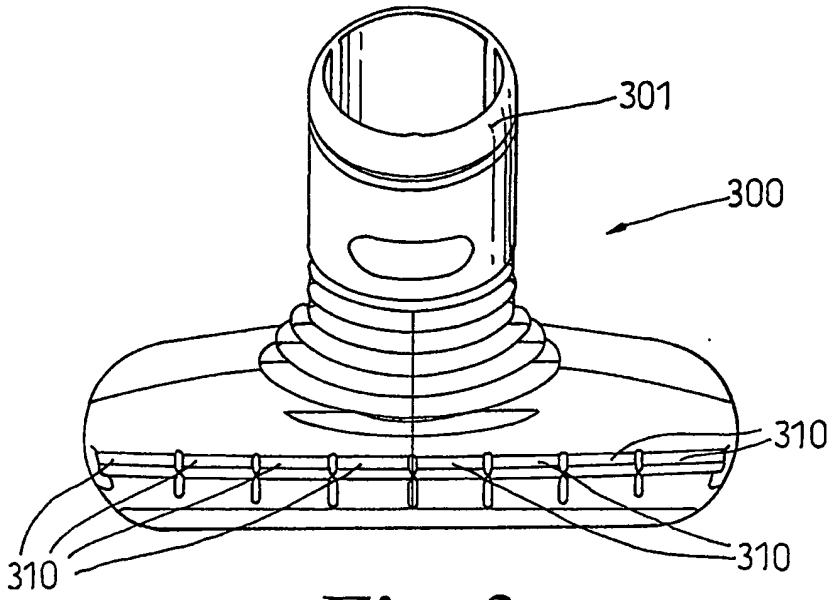


Fig. 3

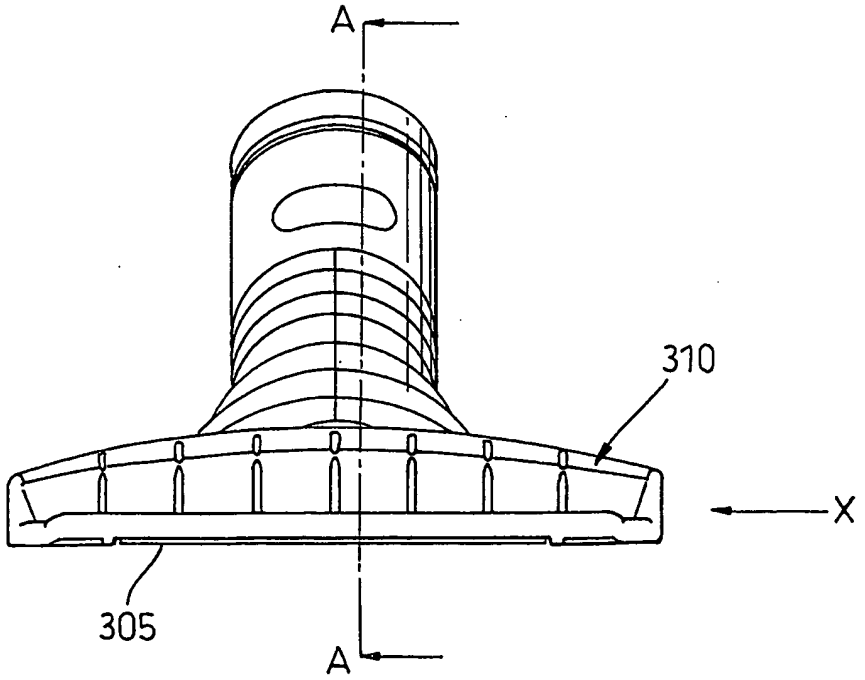


Fig. 4

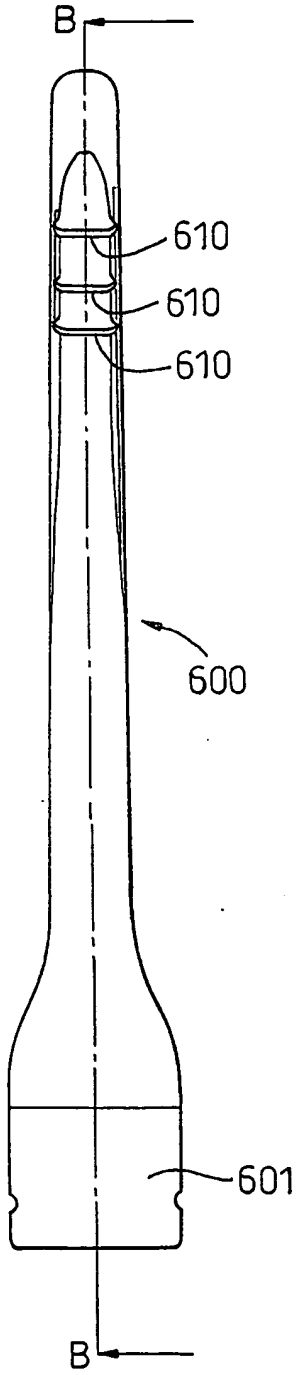


Fig. 6

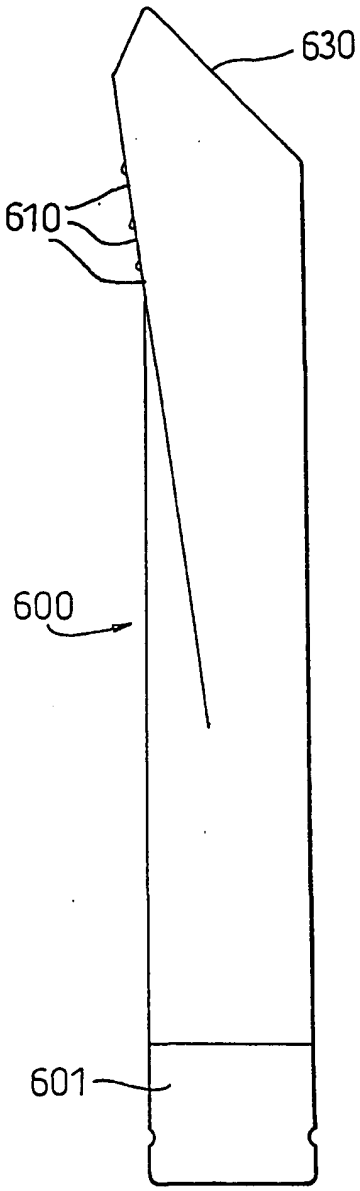


Fig. 7

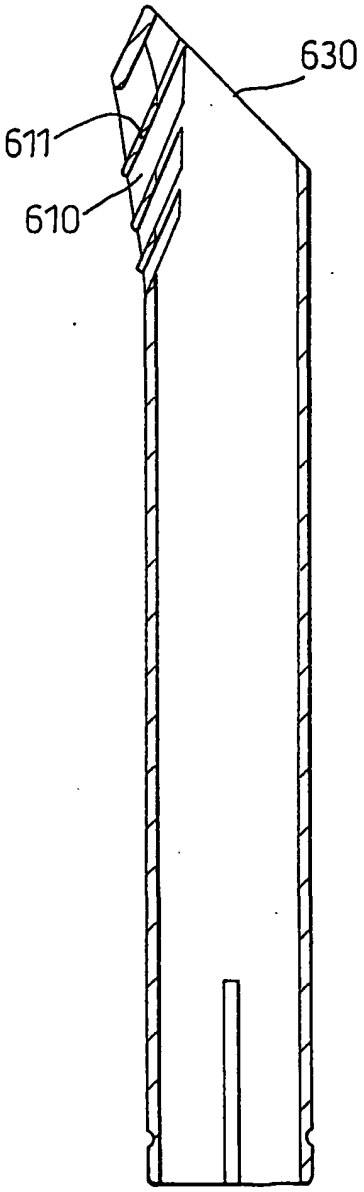


Fig. 8

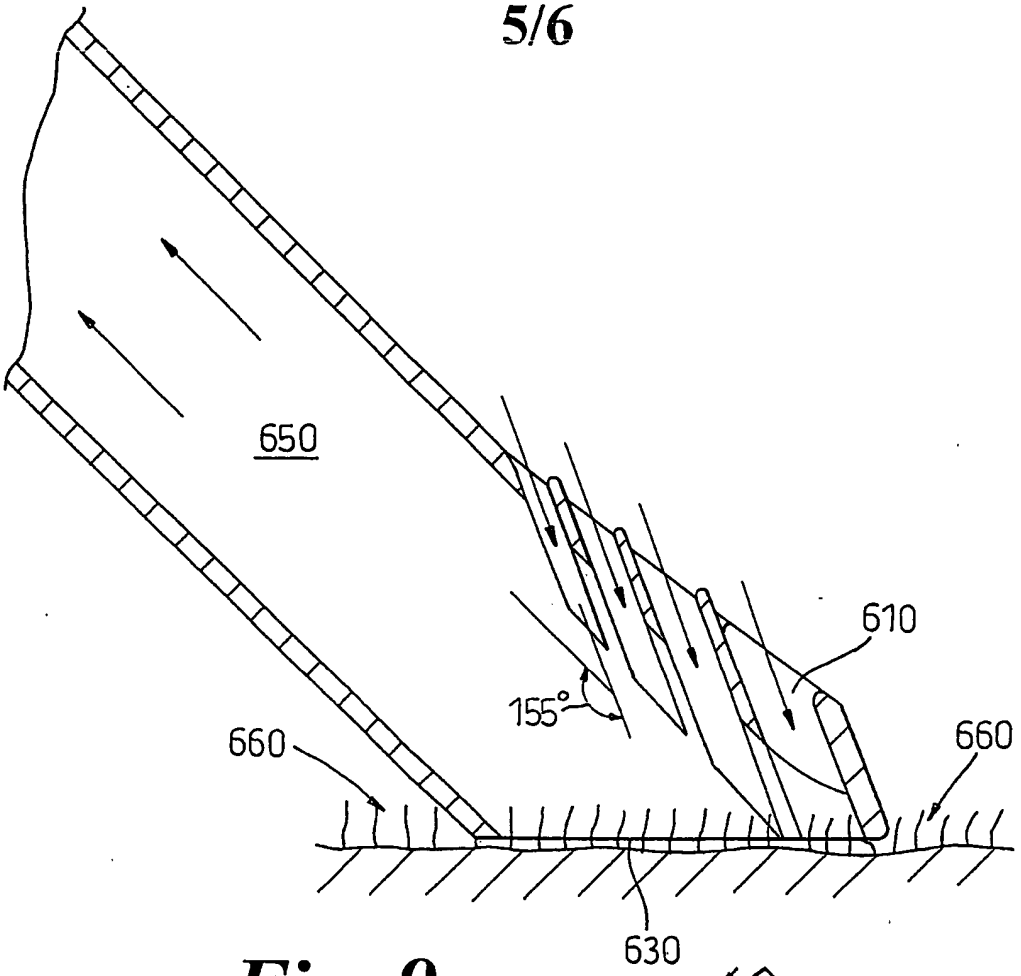


Fig. 9

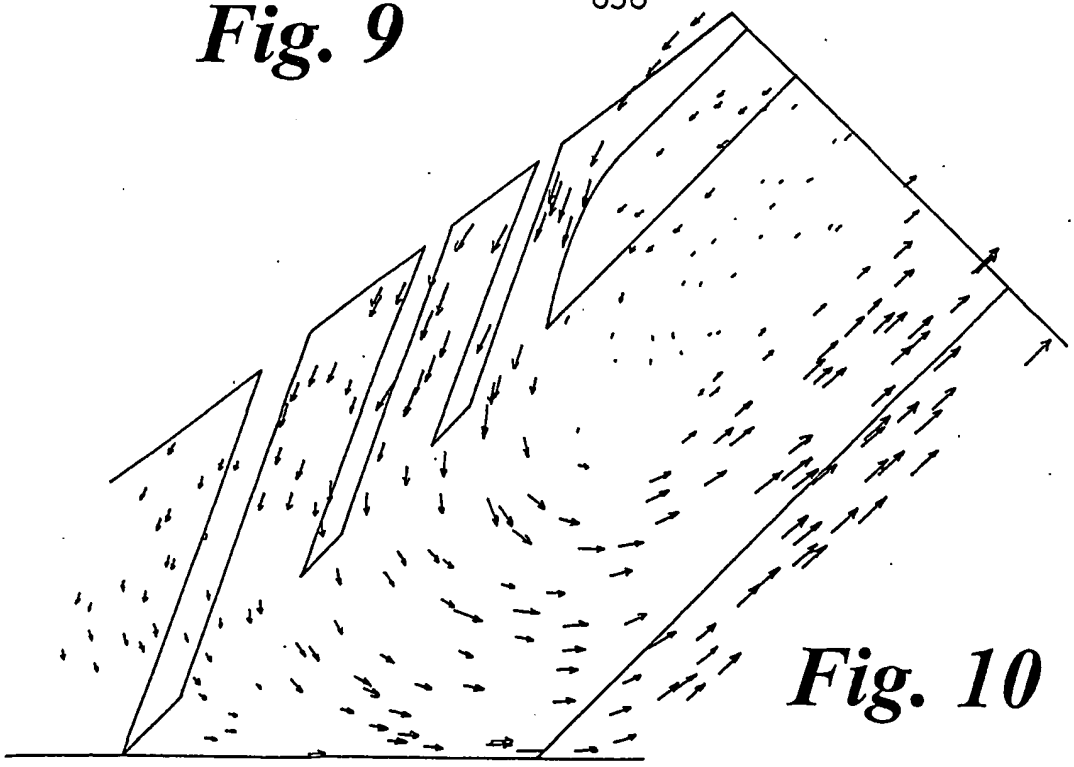


Fig. 10

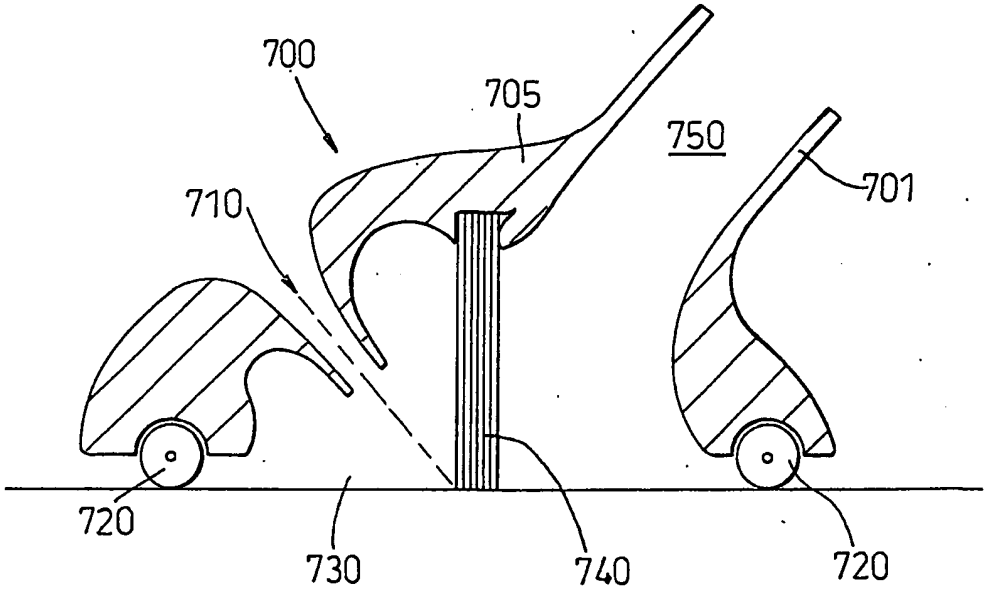


Fig. 12

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/00609

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A47L9/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 315 231 A (NOTRETY LIMITED) 28 January 1998 (1998-01-28) the whole document	1-5,7,9, 10,12, 14-16
Y	BE 721 011 A (LE SUPER) 3 March 1969 (1969-03-03) page 2, paragraphs 2-4, 10, 11 page 3 page 4, line 1 claims 1-4,6,8,9; figures	1-5,7,9, 10,12, 14,16
A		6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 May 2002	05/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Bourseau, A-M

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/00609

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 032 328 A (REXAIR, INC.) 7 March 2000 (2000-03-07) abstract column 1, line 36 - line 63 figures	15
X	GB 958 445 A (SIEMENS-ELECTROGERÄTE AKTIENGESELLSCHAFT) 21 May 1964 (1964-05-21) page 1, lines 21-42, 52-81 claims; figures	1-3, 7-10,12
A		3-5,11, 12
A	US 4 091 496 A (W. DESROSIERS ET AL.) 30 May 1978 (1978-05-30) column 1, lines 19-23, 34-41 column 2, lines 21-37, 51-58 column 3, line 10 - line 20 figures	1-3,7, 9-11,16
A	FR 1 434 272 A (SOCIETE DE PARIS ET DU RHÔNE) 8 April 1966 (1966-04-08) the whole document	1-8
A	DE 16 28 562 A (H. DETERMANN) 18 February 1971 (1971-02-18) the whole document	1-7

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 02/00609

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
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